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Report

VHF (BAND II) PROPAGATION TESTS ACROSS THE IRISH SEA

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Summary

Measurements of Band II transmissions across the Irish Sea over a 13-month period between 1983 and 1984 have been analysed and compared with prediction methods normally used to calculate interference from broadcast transmissions (BBC and CCIR methods). They were also compared with North Sea measurements made in 1954.

The measurements show that both methods predict interference levels which are not seriously in error, any differences which do exist tending to allow a slightly greater degree of protection than may be necessary. Considering how different the two methods are in their approach to field strength prediction, it is encouraging to note how closely they agree with each other.

When compared with the earlier North Sea measurements, the results showed a possible anomaly regarding the effect of transmitter height on received field strength for trans-horizon paths. Whilst not a serious problem, it does raise questions concerning the mechanism of trans-horizon propagation at VHF which cannot be fully explained.

Index terms: *VHF; field strength; propagation; interference; prediction*

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1. INTRODUCTION

Only a limited amount of information exists on medium to long distance propagation at Band II frequencies in the United Kingdom. Some tests were made in 1954 between the Netherlands (Scheveningen) and the East coast but it has long been thought that more work should be done, particularly with the expansion of VHF radio and the possibility of increasing interference problems. Unfortunately this expansion has meant that there is relatively little unused spectrum left to carry out such tests.

However, until recently, there was enough signal along the north west coast of England from an RTE transmitter at Kippure to enable sensible field strength recordings to be made. This transmitter radiated the Irish Radio 2 national programme on 95.3 MHz. Unfortunately in 1985 the situation changed due to reorganisation of the Irish Band II frequency plan and the Kippure transmission moved to 91.3 MHz. Then, because of UK Local Radio transmissions on the same frequency, it became un-measurable. In the year prior to the change the opportunity was taken to investigate propagation across the Irish sea using the 95.3 MHz transmission.

2. MEASUREMENT SITES

Three sites were chosen around Morecambe Bay, two near sea level and on the coast (Coast Guard stations at Fleetwood and Walney Island) and one further inland but about 120 metres above sea level (British Telecom link station at Dalton-in-Furness). Local clutter, either trees or buildings, was completely absent at these sites.

The geographical relationships are shown in Fig. 1. A calibrated measuring receiver and antenna system together with a chart recorder were installed at each location. Technical details of the transmitter and receiving sites are given in Appendix 1.

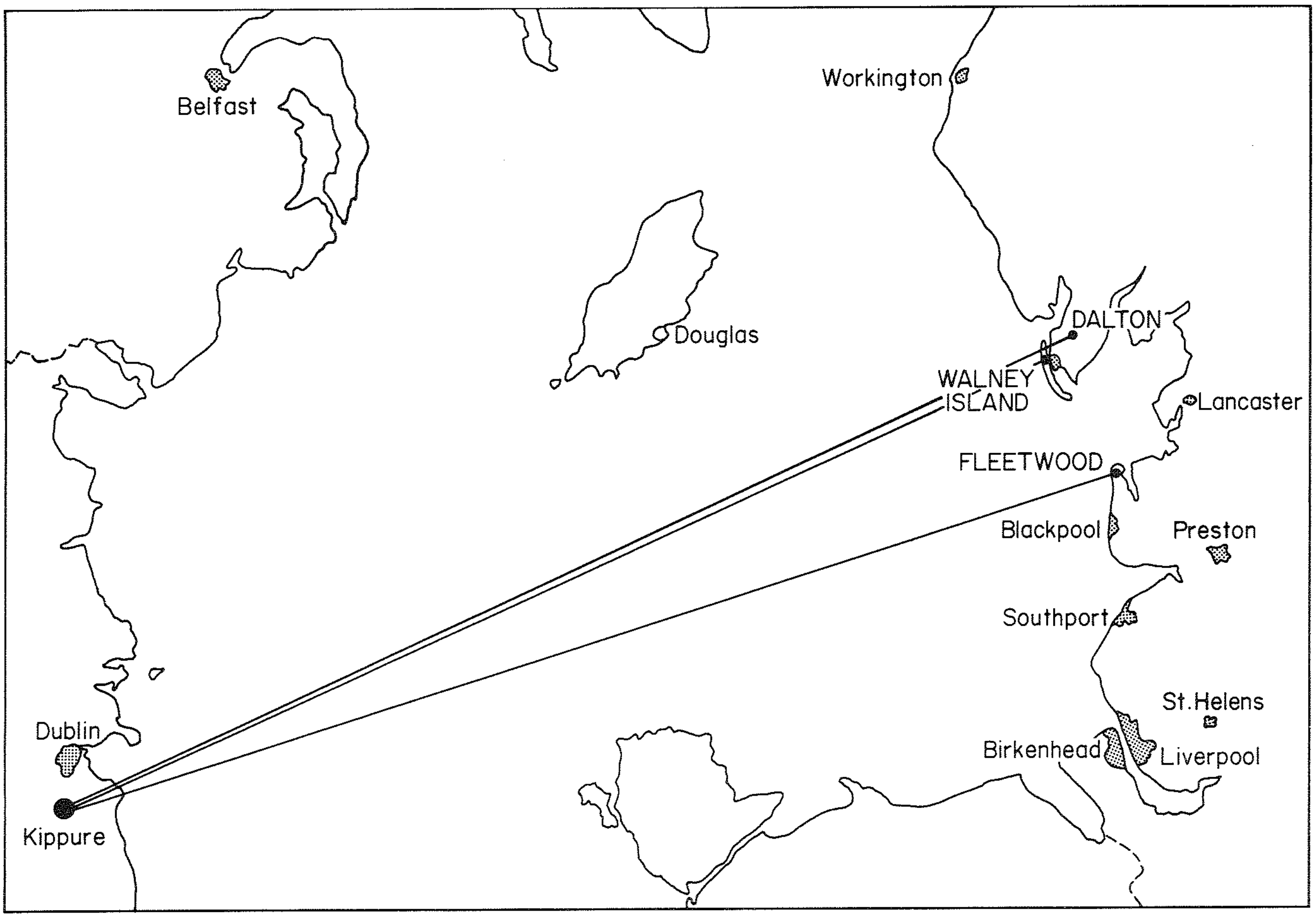

Fig. 1 - Transmitting and receiving site locations.

3. RESULTS

3.1 Analysis of measurements

Throughout the 13-month period, from November 1983 to November 1984, the transmissions were continuous, although equipment problems, mainly with the chart recorders, reduced the effective measurement time to about 88%. Fig. 2 shows the variation of the mean monthly field strengths.

The analysis of the charts was done manually and was based on the number of minutes that the signal exceeded a given level in every 24-hour period. This was a formidable task in which approximately 2,000 metres of paper chart were analysed*. The levels which were exceeded for 1%, 5% and 50% time are summarised in Appendix 2. These were found to lie on straight lines when plotted on probability paper, as shown in Fig. 3, indicating log-normal distributions with standard deviations of between 8 and 9 dB, i.e. a difference of about 20 dB between the 1% and 50% time levels.

3.2 Height gain at the receiving sites

In Fig. 3 it can be seen that there is a variation in level between the three receiving sites. All three paths have fairly similar characteristics, the only factor which is significantly different being receiving site height which varies from 15 metres (a.m.s.l.) at Fleetwood to 129 metres (a.m.s.l.) at Dalton. If the measured field strengths (see Appendix 2) are normalised to the mean distance (232 km) and plotted against receiving antenna height then there is a near logarithmic relationship in which field strength increases with height, as seen in Fig. 4.

The implication here is that the incoming signals are the result of a predominately 2-ray propagation effect. This would be expected for the low percentage time levels but not for 50% time, where tropospheric scatter is generally considered to be the main mode of propagation.

Examples of typical signal variations are shown in Figs. 5 and 6. Fig. 5 shows the higher level, slowly varying signal which gives rise to the 1% and 5% levels and is caused by homogenous reflecting layers in the troposphere (inversion layers) occurring with certain weather conditions. With this type of propagation, direct and sea-reflected paths are likely to exist and receiving antenna height gain would be expected.

Fig. 6 shows the rapidly fluctuating signal which existed for much of the time and accounts for the 50% time level. It is normally assumed that this type of signal variation is caused by scattering from

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* In future, work of this nature will be done using computer-based data logging techniques, but at the time of the measurements such equipment was not available.

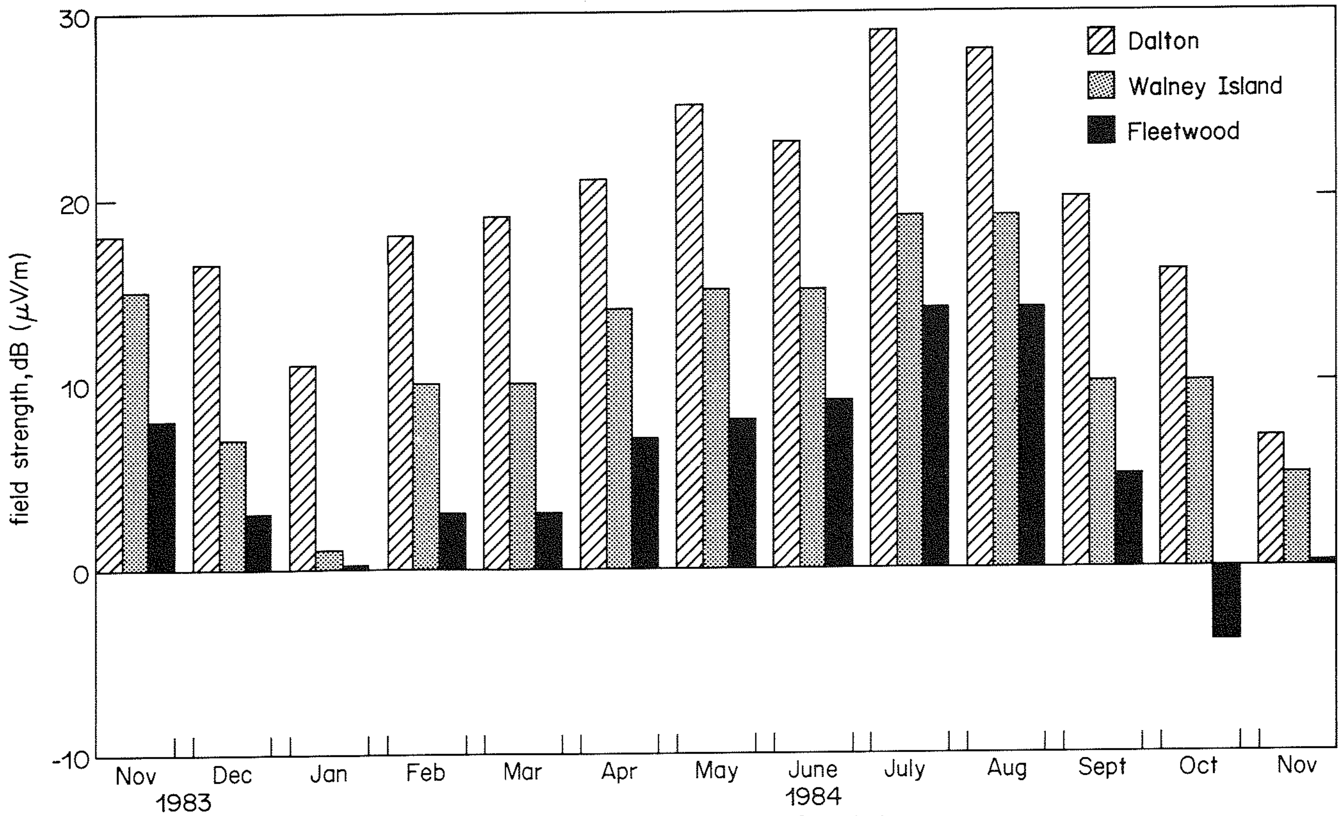

Fig. 2 - Mean monthly field strength variation.

Values have been normalised to an effective radiated power of 1 kW.

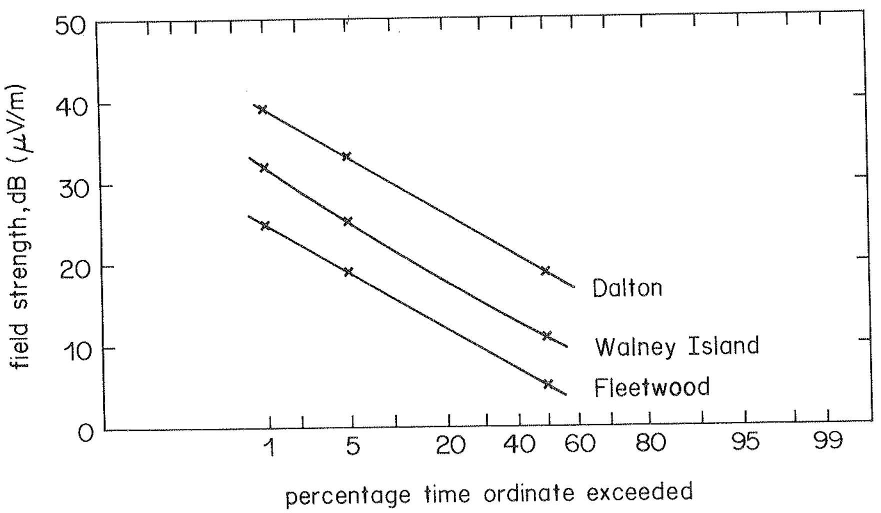

Fig. 3 - Reception of 95.3 MHz transmissions from Kippure at Fleetwood, Walney Island and Dalton between November 1983 and November 1984.

Field strengths have been normalised to an effective radiated power of 1 kW.

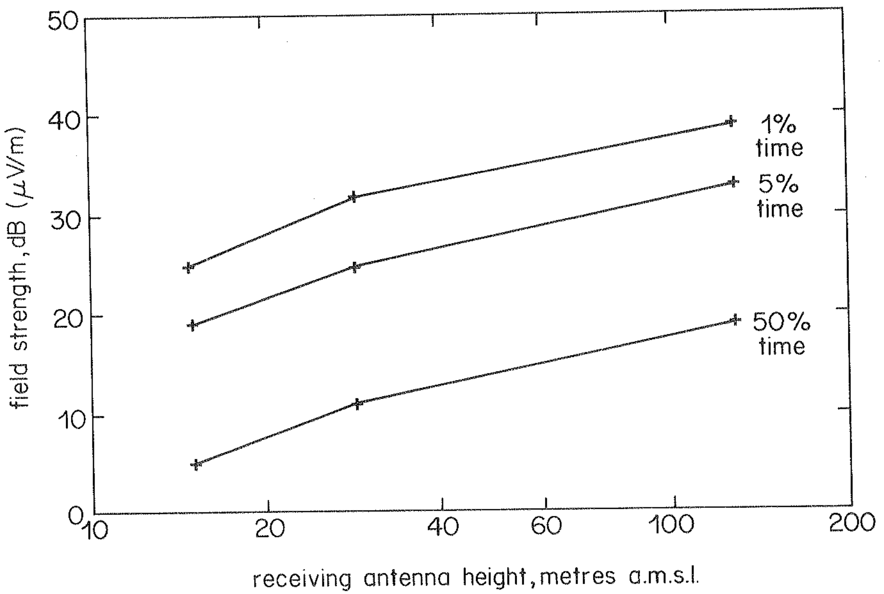

Fig. 4 - Variation of received field strength with receiving antenna height (a.m.s.l.).

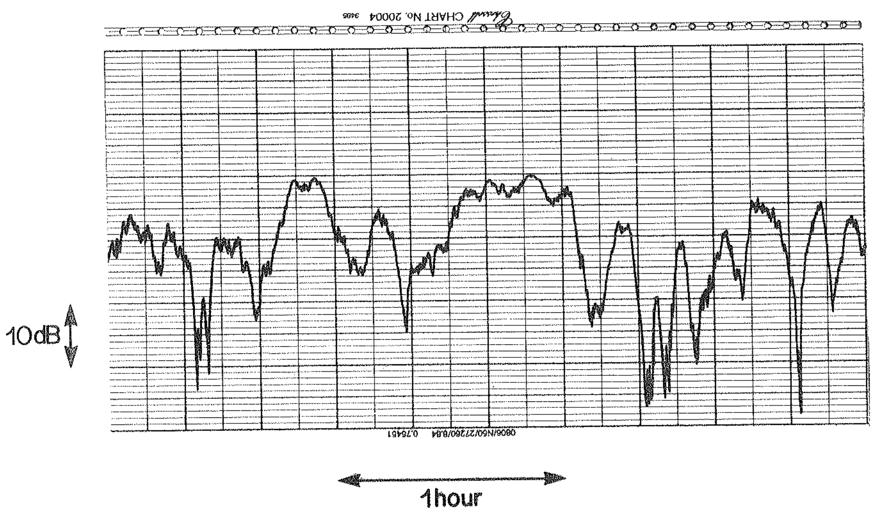

Fig. 5 - Typical received signal attributable to inversion layer propagation.

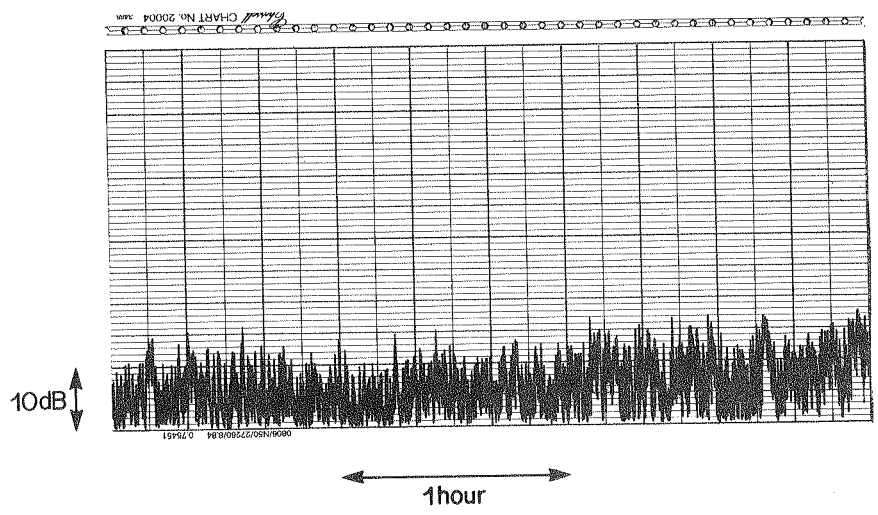

Fig. 6 - Typical received signal attributable to scatter propagation.

small-scale refractive index irregularities always present in the troposphere, which are themselves caused by random turbulent air movements. At any instant in time there will be many individual propagation paths between transmitter and receiver, producing signals at the receiver with widely differing amplitudes and phases. These signals add vectorially, but because the relative phase of each component signal is changing rapidly with time, there is no coherent resultant signal. Therefore the existence of a height gain effect for the 50% time level, as shown by the measurements, is rather surprising.

A possible explanation is that diffraction effects are also being observed, and these are sensitive to antenna height. It is normally assumed, however, that diffracted signals over such distances are much lower in amplitude than those arriving via the troposphere.

3.3 Comparison of measurements with predictions

Predictions were made using the BBC VHF interference prediction programme and also CCIR Recommendation 370[1]. In the latter case, terrain angle correction was incorporated but not Δh correction since the propagation paths are predominately over the sea. The differences between predictions and measurements are given in Table 1. A summary of the measured and predicted field strengths, from which Table 1 is derived, is given in Appendix 2.

It can be seen that the mean differences (prediction-measurement) vary from 2 dB to 8 dB with the greatest individual differences occurring at 1% time. There is relatively little difference between the two prediction methods, both tending to predict higher values than measured. However they are very different in their approach to field strength prediction. The CCIR method is entirely empirical whilst the BBC method is based on propagation theory with optimisation using some measured data. It is therefore encouraging to see that they give such similar results, particularly since, normally, the CCIR method is used for international co-ordination and the BBC method for domestic planning.

3.4 Comparison of measurements with earlier work

In 1954 propagation measurements were made across the North Sea between Scheveningen in the Netherlands and Happisburgh in Norfolk, at a frequency of 94.35 MHz[2]. The path length is similar to the Irish Sea paths and it is believed that weather conditions at the time were comparable to those in 1984, i.e. there were no abnormal conditions. It is therefore interesting to compare the old with the new measurements.

Of the three Irish Sea receiving sites, Walney Island is more comparable to Happisburgh, being on the coast and free from urban clutter and with an antenna height only five metres higher than at Happisburgh. The measurements are compared in Table 2.

The similarity between these two sets of field strength measurements is remarkable, not only because there are 30 years between them, but because the transmitting height at Kippure is 813 metres whilst that at Scheveningen is only 59 metres (a.m.s.l.). (The slight difference in path length contributes only about 1 dB to the path loss and the difference in receiving antenna height is assumed to be negligible.)

The fact that such a large difference in transmitting antenna height has apparently no effect on the received signal strength is hard to accept, particularly in view of the height gain effects observed at the receiving terminals.

It may have been that the radiated power from Kippure was lower than that stated by RTE, or that the power radiated by Scheveningen in 1954 was higher. However both explanations are unlikely since large errors in transmitter power would have been apparent in other more obvious ways. Errors in

Table 1

Differences (dB) between field strength predictions and measurements (p-m) over a 13-month period.

	1% time		5% time		50% time	
	BBC	CCIR	BBC	CCIR	BBC	CCIR
Kippure-Fleetwood	6	13	6	9	6	7
Kippure-Walney Island	7	7	3	4	4	2
Kippure-Dalton	12	4	2	−1	−2	−2
Mean difference	8.3	8.0	3.7	4.0	2.7	2.3
Standard deviation	3.2	4.6	2.1	5.0	4.2	4.5

Table 2
Comparison of measured field strengths between Scheveningen-Happisburgh and Kippure-Walney Island paths.
(Field strength measurements normalised to 1 kW ERP)

	Path length	Transmitter height (a.m.s.l.)	Receiver height (a.m.s.l.)	1% Field strength (dBμV/m)	5% Field strength (dBμV/m)	50% Field strength (dBμV/m)
Kippure-Walney Island	228	813	29	32	25	11
Scheveningen-Happisburgh	203	59	24	30	25	11
Differences	25	754	5	2	0	0

receiving system calibration are also extremely unlikely since considerable care was taken in calibrating the antennas, feeders and measuring receivers. The antennas used were conventional 3-element designs having gains which were easily verifiable using standard techniques. Furthermore, three separate measuring sites were used for the Irish Sea measurements and all showed good correlation.

The predicted results for these paths are compared in Table 3.

It can be seen that both methods show dependence on transmitter height, the BBC prediction indicating increases in field strength of 8 dB to 11 dB and the CCIR prediction increases of 5 dB to 8 dB. These increases arise from path geometry considerations in conjunction with empirical data, which for this type of path would have been the 1954 Scheveningen-Happisburgh results. Although data relating to higher transmitter sites was available, very little of it related to sea-paths of this distance. The Scheveningen transmitter was the only one used for sea-paths where any significant amount of data was obtained.

The recently obtained Irish Sea data from the transmitter at Kippure, where the height was many times greater than at Scheveningen, indicates that signal strength may be less dependent on transmitter height than was previously thought; at least for trans-horizon sea-paths. The reasons are not clear and a carefully controlled experiment using simultaneous transmissions from high and low sites would need to be made to confirm this. If it is true, then both prediction methods are at present over-estimating signal levels from high transmitting sites for trans-horizon paths. Apart from giving a degree of over-protection from interference, this is not a serious problem.

4. CONCLUSIONS

Between 1983 and 1984 continuous field strength measurements were made of Band II transmissions across the Irish Sea from the transmitter at Kippure.

Apart from North Sea measurements made in 1954, relatively little data exists for trans-horizon sea paths at Band II. This was the last opportunity to obtain further information because re-organisation of the Irish Band II frequency plan in 1985 would move the Kippure transmissions to 91.3 MHz. Then, UK Local Radio transmissions on the same frequency would make measurements impossible.

The data have been analysed and the results compared with the measurements made in 1954 and with the BBC and CCIR prediction methods. Comparison with the measurements made in 1954

Table 3
Comparison of predicted field strengths between Scheveningen-Happisburgh and Kippure-Walney Island paths.

	1% Field strength		5% Field strength		50% Field strength	
	BBC	CCIR	BBC	CCIR	BBC	CCIR
Kippure-Walney Island	39	39	28	29	15	13
Scheveningen-Happisburgh	28	34	20	24	4	7
Differences	11	5	8	5	11	6

indicated that transmitter height appears to make surprisingly little difference to the received field strength. This is in contradiction to both the BBC and CCIR prediction methods which assume that field strength is proportional to transmitter height. Resolution of this anomaly would require the measurement and analysis of many more paths, which seems impossible due to the lack of interference-free RF spectrum.

The implication is that interference prediction for trans-horizon sea paths could give field strength levels which are too high. However, whilst a safety margin may exist, it is not so great as to warrant changes to the prediction methods, particularly on the limited amount of evidence available.

5. ACKNOWLEDGEMENTS

The BBC acknowledges with grateful thanks the Ministry of Transport and Civil Aviation and British Telecom for permission to install recording equipment at the Fleetwood and Walney Island Coastguard sites and the Dalton link station respectively. The author also wishes to thank Mrs. K. Agate and Mrs. J. Movahedi for their untiring effort in analysing the 2000 metres of chart recordings produced by this equipment.

6. REFERENCES

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2. TAPLIN, D.H., et al. 1956. Final report on the long distance propagation of a very high frequency (94.35 Mc/s) over the North Sea, 1st July 1954 - 30th September 1955. BBC Research Department Report No. K-107/2 (1956/40).

APPENDIX 1

Transmitter and Receiving Site Details

Transmitter details

Name:	Kippure
Location:	NGR IO 115154
Site height:	753 metres a.m.s.l.
Antenna height:	60 metres a.g.l.
Frequency:	95.3 MHz
Polarisation:	Vertical
ERP in the direction of Fleetwood:	26.8 kW
ERP in the direction of Walney Island:	24.4 kW
ERP in the direction of Dalton:	24.4 kW

Receiving site details

Fleetwood (Coastguard Station)

Location:	NGR SD 315479
Distance from transmitter:	233 km
Bearing from Kippure:	66.3 Deg EGN, 67.6 ETN
Site height:	5 metres a.m.s.l.
Antenna height:	10 metres a.g.l.

Walney Island (Coastguard Station)

Location:	NGR SD 173690
Distance from transmitter:	228 km
Bearing from Kippure:	60.1 Deg EGN, 61.4 ETN
Site height:	20 metres a.m.s.l.
Antenna height:	9 metres a.g.l.

Dalton (British Telecom link site)

Location:	NGR SD 223755
Distance from transmitter:	235 km
Bearing from Kippure:	59.2 Deg EGN, 60.5 ETN
Site height:	122 metres a.m.s.l.
Antenna height:	7 metres a.g.l.

APPENDIX 2

Summary of Measurements and Predictions

	1% F/S			5% F/S			50% F/S		
	Meas	BBC	CCIR	Meas	BBC	CCIR	Meas	BBC	CCIR
Kippure-Fleetwood	25	31	38	19	25	28	5	11	12
Kippure-Walney Island	32	39	39	25	28	29	11	15	13
Kippure-Dalton	39	51	43	33	35	32	19	17	17
Scheveningen-Happisburgh	30	28	34	25	20	24	11	4	7

(Field strength values are in dB(μV/m), normalised to an effective radiated power of 1 kW).

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